

# HEXANCHUS VITULUS, A NEW SIXGILL SHARK FROM THE BAHAMAS

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## ABSTRACT

Examination of a larger number of sixgill sharks (family Hexanchidae) from the coasts of North America than have hitherto been available shows that two well-differentiated species occur in the western North Atlantic. The larger of the two Atlantic species, *Hexanchus griseus*, has been taken rarely in the western North Atlantic where it is known only from specimens 2.90 meters or more in length. The smaller Atlantic species, *Hexanchus vitulus*, is described and illustrated from types collected off Bimini, Bahamas. The small species becomes sexually mature at about 1.40 to 1.75 meters and apparently does not reach a much greater length.

## INTRODUCTION

In this report we describe a new species of sixgill shark or cowshark (family Hexanchidae).

The lack of large *Hexanchus* preserved as entire specimens and the paucity of small specimens in study collections prevent making a really satisfactory review of the genus on a worldwide basis. Most of the study material we have seen is from the western North Atlantic and from the eastern North Pacific. Bigelow & Schroeder (1948) regarded *H. corinus*, and all other names for extant *Hexanchus*, as synonyms of *Hexanchus griseus* (Bonnaterre, 1780), but, although their references to the literature numbered more than a hundred, the study material they listed included only one specimen from the Mediterranean, one from the coast of Cuba, two from the Pacific coast, and three dry jaws from the western North Atlantic. We have been able to assemble only a little more data from specimens and records; the newly available specimens are critical, however, because they include sexually mature examples of the form described here as a new species.

We cannot reach a conclusion on the status of *H. corinus* of the eastern Pacific on the basis of material available. None of the sixgill sharks of the eastern Pacific are recorded positively as being sexually mature; we are uncertain that a full-grown sixgill shark has ever been landed in the region, although young and half-grown specimens are often taken. Since the nominal species of the eastern Pacific are similar to *H. griseus*, if not identical, we have merely indicated the ways in which our new species differs from Atlantic-Mediterranean examples of *H. griseus*.

The lack of specimens for study is partly due to the very large size at-

tained by some of the sixgill sharks and the difficulty in catching, handling, and preserving very large sharks that live in relatively deep water. The records of capture of sixgill sharks suggests that, although the geographical range of large specimens is very extensive, the young may be restricted to regions near a few nursery areas. In view of the difficulties in obtaining specimens, especially the larger ones, we are describing now the small species that is common in the West Indian region with the expectation that this account will simplify critical examination of large and small specimens from other parts of the world and lead to a better understanding of this interesting group.

The name for the new species is from the Latin for calf or bullock: hence *vitulus*, for a small cowshark.

### ***Hexanchus vitulus* new species**

*Holotype*.—U. S. National Museum No. 200674, a mature male, 148 cm long, collected by Perry W. Gilbert near Bimini, Bahamas, from a depth of about 350 meters in July, 1963.

*Paratype*.—USNM No. 200675, a mature female, 142 cm long, collected with the holotype.

*Other Specimens Examined*.—USNM No. 186120, a 58-cm, young female from 155 meters depth, 29°02'N, 85°46'W, August 27, 1957; 162-cm, sexually mature female collected from about 300 m depth by Sr. Sanchez-Crowley off Cojimar, Cuba, May, 1943; dried jaw, USNM No. 110900, without data; 2 mature females, 163 cm (dried jaw, USNM No. 11260) and 169 cm, collected from about 275 m depth by S. Springer off Bimini, Bahamas, June 6, 1948; 2 mature females, 170 and 173 cm, collected from about 290 m depth by B. W. Winkler off West End, Bahamas; and dried jaw, Museum of Comparative Zoology, Harvard, No. 36216, without data. We tentatively refer Stanford University Natural History Museum No. 30642, 2 embryos, 42 and 43 cm, from Dumaquete, Philippines, to this species.

*Records*.—Seven mature females, 158 to 178 cm (some said to have embryos—B. W. Winkler, personal communication), and 2 adult males, 153 and 157 cm, collected at depths from 90 to 140 m off Bluefields, Nicaragua, and Port Limon, Costa Rica; MCZ No. 35630, a 43-cm female from Havana, illustrated in Bigelow & Schroeder (1948:fig. 9,A).

*Diagnosis*.—*Hexanchus vitulus* is a small species that becomes sexually mature at a length of 140 to 175 cm and probably reaches lengths not much greater than 180 cm. In contrast, *H. griseus* is reported to reach lengths greater than 450 cm.

*H. vitulus* has only five rows of large trapezoidal teeth on each side in the lower jaw, whereas *H. griseus* has six rows. We have found no exceptions in the material we have examined.

*H. vitulus* differs from *H. griseus* in body proportions, but because of allometry it is difficult to use proportional measurements for the identification of single specimens. In all of the material we have examined, however, *H. vitulus* has a proportionally larger eye and longer snout (measured from the front of the mouth) than *H. griseus*. Also, a proportionally greater distance separates the bases of the dorsal fin and anal fin from the origin of the caudal fin than in *H. griseus*.

Shapes of fins may also prove to be useful diagnostic characters, at least in comparison of young specimens. In *H. vitulus* the distal margin of the pectoral fin is somewhat concave both in adults and in the young. Young *H. vitulus* have a slightly more definite lower caudal lobe than young *H. griseus*. We are uncertain about details of fin shape in large *H. griseus*, since our data on specimens are from photographs and from incomplete field notes and measurements.

The upper margin of the distal half to nine-tenths of the caudal fin carries a series of enlarged denticles in all examples of *Hexanchus* that we have seen, but the prominence of these denticles and their size relative to the size of denticles on the sides of the caudal fin are reduced in large specimens. Adults of *H. vitulus* and also large specimens of *H. griseus* have the enlarged denticles only on the distal half of the caudal fin. In *H. vitulus*, however, the lateral surface of the upper distal portion of the caudal fin of the adults is covered by imbricate denticles of nearly uniform size, whereas in the single large example of *H. griseus* (a 433-cm female) that we have examined in detail, denticles of that area were of various sizes, irregularly distributed, and not imbricate.

*Description of Holotype*.—Body moderately slender, depth of trunk about equal to width, no caudal pits or keels, length of head to sixth gill slit 19.3 per cent of total length, tail 29.7 per cent, tip of snout to anus 47.3 per cent.

Head moderately flattened, regularly tapered from first gill slit to nostrils, abruptly rounded anterior to nostrils (see Fig. 1); nostrils much nearer tip of snout than forward edge of mouth, inner-posterior part with single valve-like flap, nostrils separated by a distance about equal to length of orbit; eyes very large (iris bright green in life), orbits longer than high, their lengths about equal to length of snout in front of eye (measured on projection), anterior end of orbit in advance of mouth; mouth very large, strongly arched; no labial furrows visible when mouth is closed but a hidden one extends from outer (upper) lip to inner (lower) lip; spiracles small, slit-like, their greatest diameter about one-tenth length of orbit,

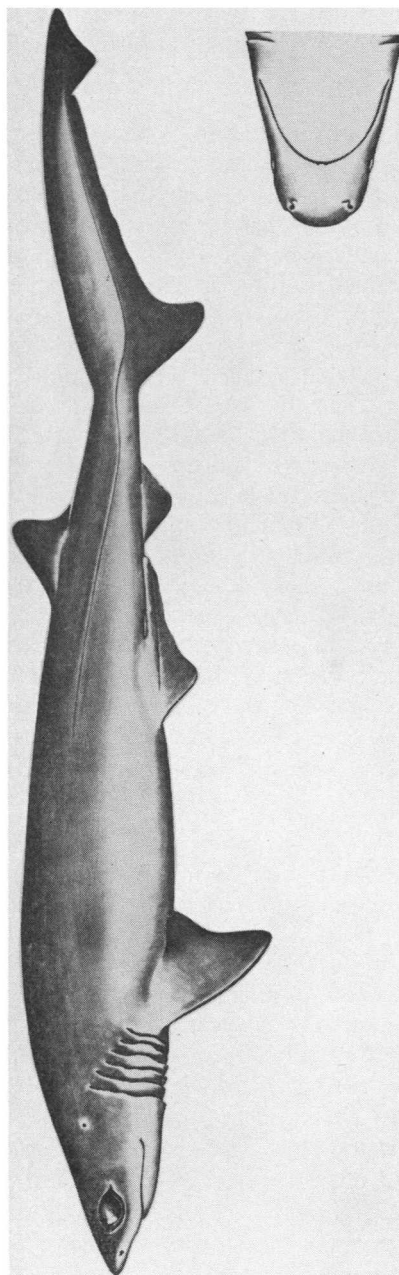


FIGURE 1. *Hexanchus vitulus*, holotype, drawn from an adult male, 148 cm long, from off Bimini, Bahamas.

located somewhat dorsal to eyes and separated from them by a distance greater than diameter of eye, nearer to upper ends of first gill slits than eye; gill slits 6, very long, first longest, progressively shorter posteriorly, sixth gill slit about half length of first.

Pectoral fins broad and short, their lengths about 11 per cent of total length, their distal margins slightly concave, origins below and posterior to midpoint of sixth gill slit; pelvic fins (of adult male) long, their posterior parts rolled around claspers forming a protective sheath; claspers (of adult male) not extending beyond protective sheath, no denticles or hooks on claspers, each clasper (from x-ray examination) supported in distal free portion by a single, simple, and cylindrical appendix-stem, appendix-stem with a clearly defined but thin surface layer of x-ray absorptive material (possibly a thin layer of calcification), a single terminal piece, apparently heavily calcified, extending alongside and slightly beyond the tip; one dorsal fin, its origin posterior to the bases of pelvics, its height about three-fourths length of its base, distance from base of dorsal to origin of caudal about two times length of dorsal base; anal fin origin below posterior half of base of dorsal fin, its base separated from origins of lower caudal lobe by a distance only slightly less than two times the length of its base; caudal fin large and long with a definite lower caudal lobe and a strong terminal lobe set off by a deep notch; no pits at base of caudal.

Teeth of upper and lower jaws of dissimilar shape, only one series of teeth functional in the lower jaw but more than one series may be functional at one time in the upper jaw; nine rows of large teeth on each side in upper jaw plus about nine rows of very small tubercle-like teeth on each side near corners of mouth, no upper symphyseal teeth, principal upper teeth of first two rows with single, strong cusps (see Fig. 2,A), cusps smooth-edged; tooth-rows 3 to 9 (counting from symphysis), first cusps progressively shorter toward corners of mouth and bases denticulate on their outer margins (toward corners of mouth); lower jaw with a single nearly symmetrical symphyseal tooth and five rows of large, trapezoidal, multicuspoid teeth on each side followed by a series of about five rows of very small tubercle-like teeth near each corner of mouth; large trapezoidal teeth with nine to 11 cusps, innermost strongest, inner margin of each large trapezoidal tooth finely serrate.

Dermal denticles relatively small, closely imbricate, with a strong central ridge and two short lateral ridges, apical points not strong; surface of skin relatively smooth to touch; a series of one to three rows of enlarged denticles on upper edge of distal half of upper caudal lobe, enlarged denticles not prominent, about two to three times the length of denticles of lateral surfaces of caudal; denticles covering lateral surfaces of caudal fin uniformly, imbricate; dermal denticles cover pelvic fins but absent on claspers.

Color plain gray, a little darker on dorsal surfaces, no prominent markings.

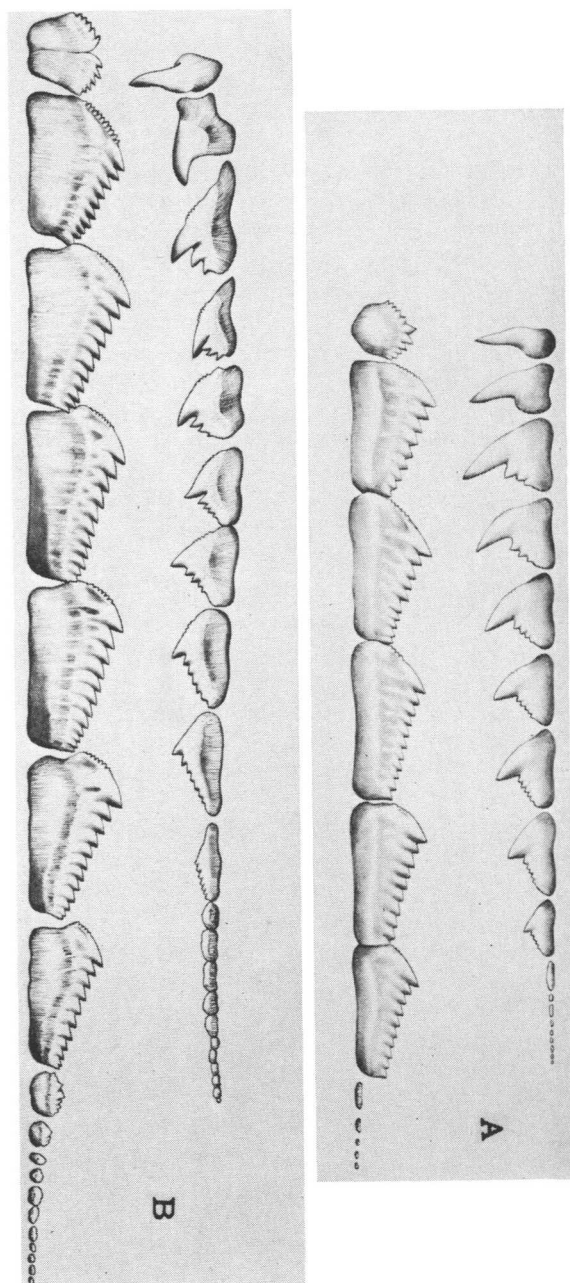


FIGURE 2. Teeth of left sides of jaws: A, *Hexanchus vitulus*, drawn from a dried jaw, USNM 110900; B, *Hexanchus griseus*, drawn from a dried jaw of a 433-cm female (no indication of sexual maturity) from the Gulf of Mexico, USNM 188048.

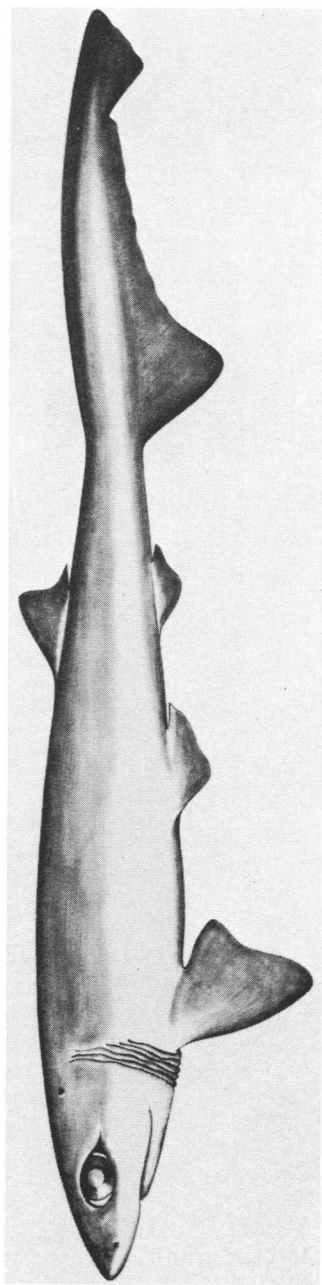


FIGURE 3. *Hexanchus vitulus*, 58-cm female from the west coast of Florida in 155-m depth.

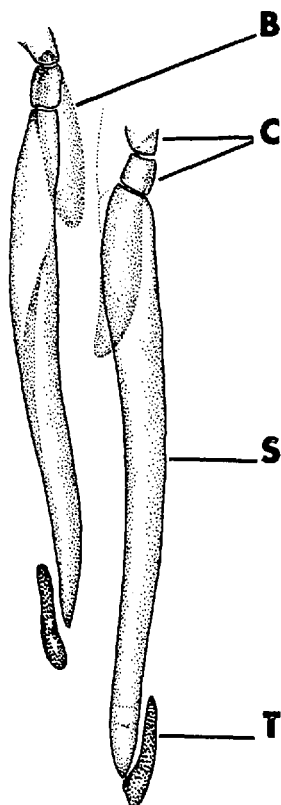


FIGURE 4. Diagram of the skeletal elements of the claspers of *Hexanchus vitulus* from radiographs of the type. (B = beta cartilage; C = connecting segments; S = appendix stem; T = terminal piece.)

*Vertebral Characters.*—Radiographs of the holotype and paratype show a few precaudal vertebrae and some of the vertebrae of the tail. None can be distinguished in the anterior portions of the trunk, although vertebrae of a bony fish in the stomach of the holotype can be counted easily. We were not able to distinguish vertebrae in radiographs of a 58-cm, young female *H. vitulus*, USNM No. 186120, nor in young specimens of *Hexanchus* from the California coast. Similarly, radiographs of the tail of the 433-cm *H. griseus*, USNM No. 188048, failed to show vertebrae and no indication of calcification could be detected by touch in the cut-through base of the tail of this specimen.

V. G. Springer & J. A. F. Garrick (1964) noted that the vertebrae in their specimens of *Hexanchus* and *Notorhynchus* were not sufficiently calcified to produce an image on a radiograph and that in *Hepttranchias* (also



in the family Hexanchidae) the precaudal vertebrae were poorly calcified. Our observations with some additional specimens bear this out, but we have not made radiographic examination of specimens of *H. griseus* or of *Notorhynchus* that we know to be sexually mature. We are not certain, for example, that the 433-cm *H. griseus* that we examined was sexually mature, and we suspect that it was not mature because we did not see ovarian eggs or embryos when the specimen was first examined in the field. The smallest gravid female *H. griseus* mentioned by Desbrosses (1938) was 450 cm long, and since the species may begin to lay down calcium in the vertebral column for the first time at sexual maturity, any determination of whether calcification of vertebrae occurs in adult *H. griseus* is impossible for us now.

*Distribution.*—Our specimens of *H. vitulus* have all been collected from the Florida–Gulf of Mexico–West Indian region, if we except the two embryos from the Philippines tentatively called *H. vitulus*. We would not be surprised to find, however, that *H. vitulus* has a very wide range in the tropical and subtropical Atlantic and in the Mediterranean, or that either *H. vitulus* or a similar species is to be found in the Indian and western Pacific oceans. Müller & Henle (1841) stated that *H. griseus* has five or six rows of broad teeth in the lower jaw. Their material is listed as from the Mediterranean and the Atlantic; we assume that it included both *H. vitulus* and *H. griseus*.

Our specimens of *H. vitulus* from the Bahama–Gulf of Mexico–Caribbean area were obtained from depths of about 90–350 meters. Commercial shark fishing with baited hooks was carried out in the area to a maximum of about 350 meters; the records of maximum depth for *H. vitulus*, therefore, may reflect merely the maximum depths fished.

*Notes on Natural History.*—Very little about the life-history and habits of *H. vitulus* can be deduced from the available specimens. Fifteen of the specimens recorded here were taken on commercial shark-fishing gear with large hooks and one- to two-pound baits. A radiograph of the type showed that the stomach contained a bait fish 21 cm long that had been swallowed in one piece. Two hooks and leader wire were also present.

The female specimens taken off Bimini from May through July had seven to 15 large eggs in each ovary; the largest eggs were about 50 mm in diameter. Captain B. W. Winkler (personal communication) found embryos in specimens taken on set lines off the Caribbean coast of Nicaragua and Costa Rica in October and November, 1948, but did not note size or number. The probable size of the young at birth is indicated by the record of a 429-mm, new-born female recorded from Havana, Cuba, by Bigelow & Schroeder (1948: Fig. 9,A). Desbrosses (1938) estimated the size of individuals of *H. griseus* at birth to be about 670 mm.

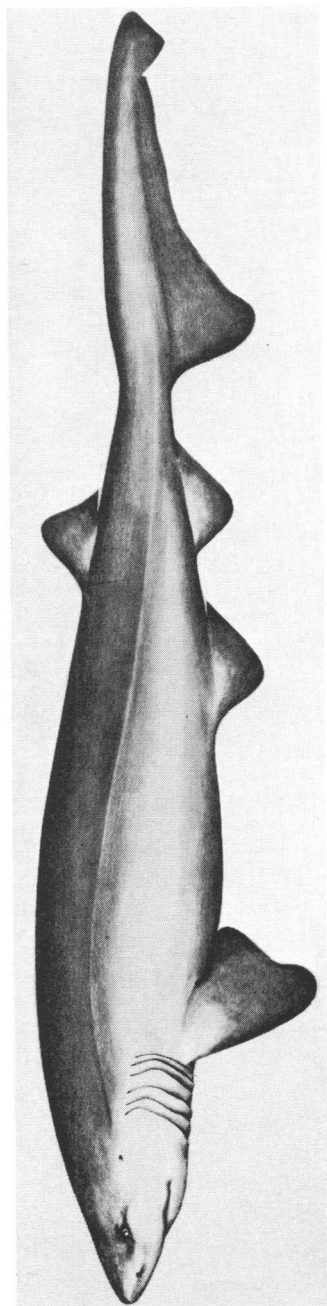


FIGURE 5. *Hexanchus griseus*, drawn from photographs and measurements of a 433-cm female from the Gulf of Mexico.

*Hexanchus griseus* (Bonnaterre, 1780)

*Material Examined from the Atlantic and Mediterranean.*—A 433-cm female (possibly immature), photographs and measurements of fresh specimen, dried jaws and tail, USNM No. 188048, from R/V OREGON station 4015 (29°04.5'N, 88°29.5'W, off the Alabama-Mississippi coast), Oct. 27, 1962; an 83-cm female, MCZ No. 946, from Nice, France (Bigelow & Schroeder, 1948, fig. 8, A-E); dried jaws of 335-cm specimen without locality data, MCZ No. 36217; a female, about 460 cm, taken by Ray Knopp from commercial shark fishing vessel off Key West, Florida.

*Other Western North Atlantic Records.*—Commercial fishing logs show a second female, 460 cm or more in length, taken off Key West, Florida, by Ray Knopp, and two immature males, 297 cm and 348 cm, taken off the Caribbean coast of Nicaragua–Costa Rica by B. W. Winkler.

*Diagnosis.*—*Hexanchus griseus* as restricted here has six rows of large trapezoidal teeth on each side of a single symphyseal tooth in the lower jaw instead of the five rows that characterize *H. vitulus*. *H. griseus* is a very large species, about 450 cm long at maturity as compared to 150 to 175 cm in *H. vitulus*. *H. griseus* also differs from *H. vitulus* in its proportionally smaller eye, shorter snout, and shorter posterior trunk region.

Questions about the identity of sixgill sharks in the western North Atlantic first occurred to one of us, Springer, in 1948 after examination of B. W. Winkler's fishing log and notes from his three-month commercial shark fishing trip to the Caribbean coast of Nicaragua–Costa Rica. These notes gave an account of the capture of two adult male sixgill sharks, 148 and 153 cm long, and two immature males, 297 and 348 cm long. This discrepancy of size suggested the possibility that two species were involved because male sharks of other species grow very little after reaching sexual maturity.

On October 27, 1962, one of us, Waller, examined a large, 433-cm sixgill shark taken in a shrimp trawl, hauled from a depth of about 360 meters on the continental slope near the mouth of the Mississippi River, south of the Alabama-Mississippi state line. The specimen was photographed and measured, the jaws were removed and dried, and the tail was preserved (jaws and tail USNM No. 188048). The specimen is shown in Figures 6 and 7 and data from it were used to reconstruct the appearance as shown in Figure 5. It was not realized at the time that there could be any questions about the identity of the shark, and since it was too large for the freezer hatch, most of the carcass was discarded after examination.

Photographs of this specimen show a somewhat pointed, cone-shaped snout that we would not have expected to be present in *H. griseus* from descriptions in the literature or from the examination of smaller specimens. If our identification of this specimen as *H. griseus* is correct, however, there



FIGURE 6. Photograph of 433-cm *Hexanchus griseus* from the Gulf of Mexico showing the pointed snout.

is a tendency for the snout to become more pointed as the shark grows to large size.

From a study of the materials and records listed in the preceding section and from a review of the literature, we have assumed that in addition to *Hexanchus vitulus* only one other sixgill shark is known from the Atlantic-Mediterranean area and that it is properly designated *Hexanchus griseus*. Since our knowledge of the species is based primarily on direct examination of one young (83-cm) specimen from Nice, France, and one large (433-cm) specimen from the Gulf of Mexico, and on the more or less general accounts of *H. griseus* in the literature, this determination needs review with more specimens than are available now in North American collections.

Our attempts to determine whether or not the nominal species of the eastern Pacific, notably *H. corinus* Jordan & Gilbert, 1880, and *H. vulgaris* Perez Canto, 1886, are separable from *H. griseus* have not been successful. We must note, however, that we have not been able to make direct comparison of series of specimens of like size.



FIGURE 7. Photograph of the head of 433-cm *Hexanchus griseus* from the Gulf of Mexico.

*Distribution.*—Sixgill sharks with six rows of large, trapezoidal teeth in the lower jaw are generally distributed throughout temperate and tropical seas, although records of capture are so irregularly scattered that they give little information on the details of distribution.

Vaillant's (1901) 452-cm mature female was taken from shallow water on the bar at Archachon, France. Such occurrences of shallow water or of beached specimens appear to be rare, however; most of the records are from specimens taken in moderately deep water. The two large specimens from the Straits of Florida, and the large one taken in a trawl off the Alabama-Mississippi coast, came from about 350 m. The ones collected off Nicaragua-Costa Rica by Captain Winkler were from depths of about 110 and 180 m. It is possible that most sixgill sharks live in depths of 350 m or more along the continental slopes, coming into shallower waters uncommonly.

On the North Pacific coast from central California to British Columbia, immature sixgill sharks are taken regularly in the deeper parts of bays. We can find no record, however, of the capture of a sexually mature *Hexanchus* in the eastern Pacific. If the size at maturity is 450 cm, failure to take adult specimens may not be an indication of their absence, because sharks that large cannot be handled by ordinary fishing gear.

Jordan & Gilbert (1880) characterized *Hexanchus corinus* from two small northeastern Pacific specimens (the larger about 108 cm) as differing from *H. griseus* of the Atlantic and Mediterranean chiefly in the form of the large teeth of the lower jaw. They stated that *H. corinus* differed in that these teeth are serrated on their inner edges, and have only six cusps instead of eight or nine. Bigelow & Schroeder (1948) pointed out that visible serration may be either present or absent on teeth of the young sixgill sharks from the Pacific coast of the United States as well as on teeth of young sixgill sharks from European waters. It is well known that the number of cusps on the large teeth of the lower jaw of sixgill sharks is greater in large specimens than small specimens. Specimens of *H. vitulus* compared with specimens of the northeastern Pacific population of sixgill sharks of equal length, however, do have an appreciably greater number of cusps. A series of five small specimens in the British Museum (Natural History), all of European origin and certainly *H. griseus*, were examined for us (personal communication, D. M. Cohen). The numbers of cusps on the large teeth of the lower jaws of the British Museum specimens do not differ from the numbers in a series of five northeastern Pacific specimens of equal lengths.

Although we do not find characters in the young sufficient to warrant recognition of *H. corinus* as separable from *H. griseus*, we recommend direct comparison of specimens of intermediate and large size, with especial attention to the shape of the head and snout and to the character of the serration on the large lower teeth. The small toothlets making up the serration of the inner edges of the large teeth of the lower jaw of the 433-cm specimen from the Gulf of Mexico are sharply pointed and triangular, about 10 in number, the central serrae largest. The serrae differ in char-

acter in one dry jaw from Port Ludlow, Washington (USNM No. 110926) that is nearly as large as the jaw of the 433-cm specimen from the Gulf of Mexico. In the jaw of the specimen from Port Ludlow, the inner margins of the large lower teeth are better described as crenulate than serrate, the tips of the raised portions are rounded and the toothlets are more than 20 in number, not notably larger in the central section of the serrate edge.

*Notes on Natural History.*—Large numbers of embryos have been reported to be carried by *H. griseus*: 108 by Vaillant (1901); 47, around 70, and 22 by Desbrosses (1938). Desbrosses also reported that the female *H. griseus* he had seen from the coast of France were immature up to lengths of 350 cm but that the gravid females that had been reported were 452, 482, 450, and 465 cm long. He also stated that he had not seen a male longer than 200 cm. Fetuses from two of the adult females were 65 to 68 cm (from Vaillant, 1901) and 67 cm in length. Desbrosses noted that juvenile specimens smaller than 67 cm had been taken in the Mediterranean and speculated that the size at birth may be smaller there. Of course, if *H. vitulus* occurs unrecognized in the eastern North Atlantic and the Mediterranean, the minimum size would conform to the size at birth of the smaller form.

Sixgill sharks, probably *Hexanchus griseus*, caught by Comores Islands fishermen were described by Foumanoir (1961) as very aggressive among themselves, often harrassing a hooked one all the way to the surface from fishing depths of 150-200 m. Their food evidently includes some rather small fishes, but they may also eat larger prey. Bigelow & Schroeder (1948) quoted Luis Howell-Rivero that dolphins, small marlin, and small swordfish are reported from *Hexanchus* stomachs (the larger *Hexanchus* are presumably all *H. griseus*). One of the specimens taken by Captain Knopp off Key West had the bill and forward part of the skull of a large swordfish (*Xiphias*) in its stomach. Contents of the stomach of the 433-cm specimen from the Gulf of Mexico were identified by Dr. D. M. Cohen as one grouper head, head length 30 to 35 cm; one *Urophycis regius*, total length 50 cm; two *Steindachneria argentea*; and one partly decomposed or digested fish, 35 cm.

#### ACKNOWLEDGMENTS

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couraged us to persist in this study over many years. Drawings are by Mary H. Wagner.

#### SUMARIO

#### *Hexanchus vitulus*, UN NUEVO TIBURON DE SEIS BRANQUIAS DE LAS BAHAMAS

El examen de un número mayor del hasta ahora disponible, de tiburones de seis branquias (familia Hexanchidae) procedentes de las costas de Norte América, muestra que dos especies bien diferentes se presentan en la parte occidental del Atlántico del Norte. La mayor de las dos especies del Atlántico, *Hexanchus griseus*, ha sido capturada raramente en el Atlántico del Norte occidental, donde es sólo conocida por ejemplares de 2.90 metros o más de longitud. La menor de las especies del Atlántico, *Hexanchus vitulus*, es descrita e ilustrada basándose en especies tipo colectadas frente a Bimini, Bahamas. La especie pequeña está sexualmente madura al alcanzar alrededor de 1.40 a 1.75 metros y aparentemente no alcanza una longitud mucho mayor.

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